In-vitro replication, measurement and characterisation of fretting wear for development of total hip replacement prostheses

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Aim

The study aims to replicate and measure the common wearing mechanism on prosthetic femoral stems, fretting wear. The wore particles from fretting wear transferred to articulating surfaces and jeopardise the lifespan and stability of total hip arthroplasty (THA).

Objectives

- ✓To determine the loading force in POP
- ✓To conduct a pin-on-plate experiment (POP)
- ✓To determine the changes in surface conditions of the plates

Background

- ✓ Total hip arthroplasty (THA) is usually the last and only resort for completely curing and improving patients' quality of lives who suffer from osteoarthritis, rheumatoid arthritis and etc.
- ✓ Various ways to perform a THA including different types of prostheses including modular/ mono blocks joint and matt/ highly polished surface (Figure 1). Hence, different wear phenomena occur.

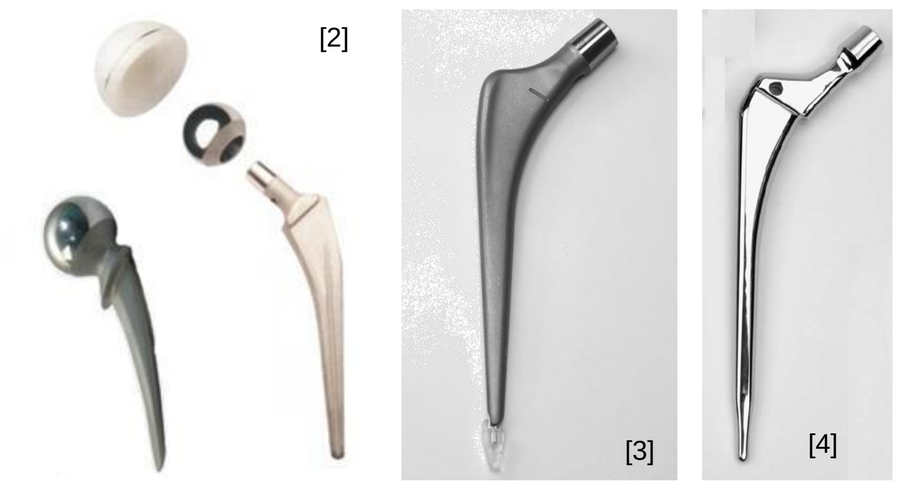
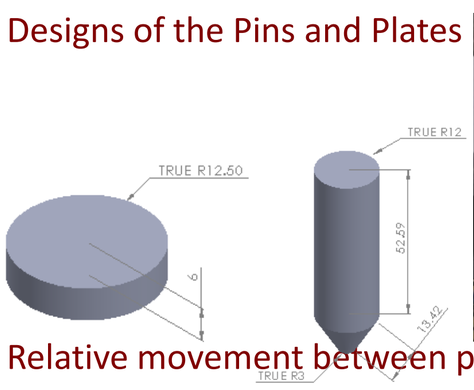


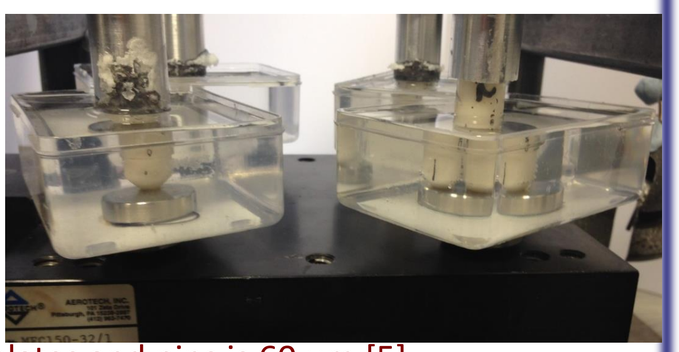
Figure 1 Different types of prosthetic joints

- ✓ Fretting wear is one of the common wear phenomenon occurs at the stem-cement interface resulting from repeated micromotions. It creates deep valleys on the surface and generates oxides which adhere to the surface.
- ✓ One of the visual evidence from fretting wear is the presence of fretting corrosion appearing as deep red oxide.
- ✓ Areal surface characterisation techniques were adopted to quantify the wear which enabled to quantify and visualise the severity of fretting wear generated in the POP experiment.
- ✓ The establishment of a repeatable measurement methods gives a useful tool for material screening in development of replacement prostheses.

Methodology and Experimental Details

- ✓ Designs of the Pins and Plates





- ✓ Relative movement between plates and pins is 60 µm [5]
- ✓ Equivalent force of 0.201 BW is applied on each pin
- ✓ Movement frequency is 3Hz [5]
- ✓ 3 Millions cycles are conducted
- ✓ Pins and plates are immersed in Ringers' Solution

References

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[4] González Della Valle, A., Comba, F., Zoppi, A., & Salvati, E. A. (2006). Favourable mid-term results of the VerSys CT polished cemented femoral stem for total hip arthroplasty.International Orthopaedics, 30(5), 381-386. doi:10.1007/s00264-006-0077-z

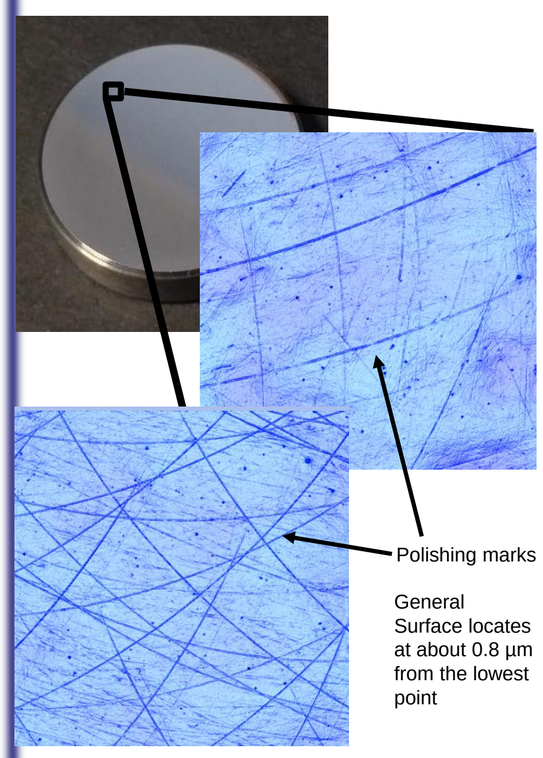
[5] Glyn-Jones, S., Gill, H. S., Beard, D. J., McLardy-Smith, P., & Murray, D. W. (2005). Influence of stem geometry on the stability of polished tapered cemented femoral stems. The Journal of Bone and Joint Surgery.British Volume, 87(7), 921-927. doi:10.1302/0301-620X.87B7.16079

3. Measurement and Results of Pins & Plates

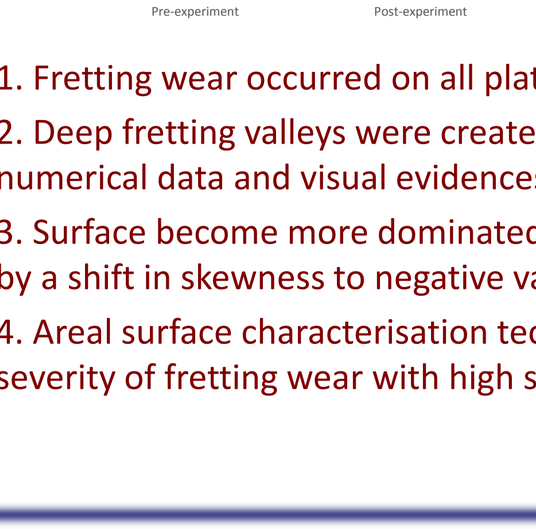
	Values	Parameters	Values
Sq (µm)	0.0209	Sds (1/mm²)	44199
Ssk	-0.5357	Vmp(um³/mm²)	782.649
Sku	317.2405	Vmc(um³/mm²)	18435.1
Sp (µm)	0.5843	Vvc(um³/mm²)	23318.8
Sv (µm)	0.6563	Vvv(um³/mm²)	2473.2813
Sz (µm)	1.2406	(Pre- experiment)	

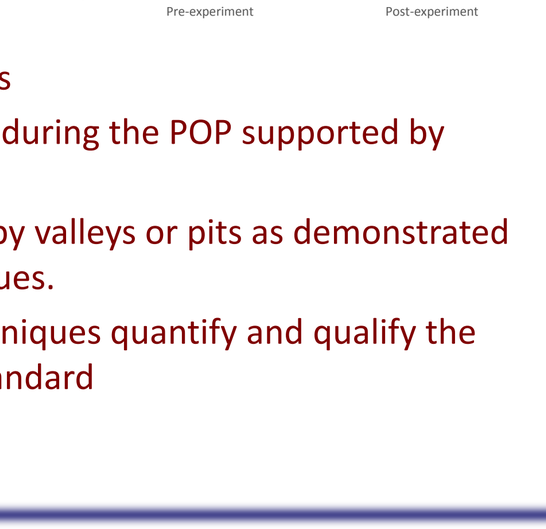
	Values	Parameters	Values
Sq (µm)	0.0731	Sds (1/mm²)	273252.5
Ssk	-3.6280	Vmp(um³/mm²)	2465.5986
Sku	333.1529	Vmc(um³/mm²)	39181.825
Sp (µm)	1.687	Vvc(um³/mm²)	41271.5
Sv (µm)	1.5673	Vvv(um³/mm²)	10510.475
Sz (µm)	3.2545	(Post- experiment)	

- ✓ 3D surface characterisaiton parameters adopted in this study were with reference to the Green Book, the output from project "Surfstand" lead by Prof. L Blunt in "SurfStand" project in 2001.
- ✓ Out of all the parameters, Skewness (Ssk) is the most important in one in the current study. This parameters shows the features dominating at the surfaces. Positive and negative values of Skewness represent peak and valleys dominant respectively .



5. Discussion & Conclusion





1. Fretting wear occurred on all plates
2. Deep fretting valleys were created during the POP supported by numerical data and visual evidences
3. Surface become more dominated by valleys or pits as demonstrated by a shift in skewness to negative values.
4. Areal surface characterisation techniques quantify and qualify the severity of fretting wear with high standard